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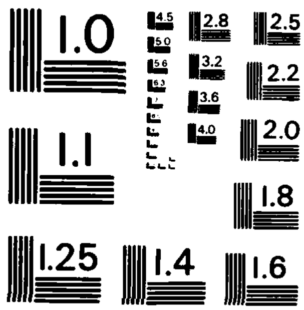
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REPORT

MRL-R-858

A GUIDE TO THE PRINCIPAL MARINE

FOULING ORGANISMS, WITH PARTICULAR

REFERENCE TO COCKBURN SOUND, W.A.

John A. Lewis

Approved for Public Release

JULY, 1982

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The principal types of marine fouling organisms collected from the marine exposure raft at HMAS STIRLING, Cockburn Sound, Western Australia, are described and twenty-nine of the most abundant species illustrated. Less common species are listed and references given to facilitate further identification of fouling species both at this site and elsewhere in Australia.

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POSTAL ADDRESS: Chief Superintendent, Materials Research Laboratories
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AUTHOR(S)

Lewis, J.A.

CORPORATE AUTHOR

Materials Research Laboratories
P.O. Box 50,
Ascot Vale, Victoria 3032

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The principal types of marine fouling organisms collected from the marine exposure raft at HMAS STIRLING, Cockburn Sound, Western Australia, are described and twenty-nine of the most abundant species illustrated. Less common species are listed and references given to facilitate further identification of fouling species both at this site and elsewhere in Australia.

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CONTENTS

A GUIDE TO THE PRINCIPAL MARINE FOULING ORGANISMS, WITH PARTICULAR REFERENCE TO COCKBURN SOUND, W.A.

1. INTRODUCTION

The settlement and growth of marine organisms on the hulls of ships and other submerged equipment continues to be a problem of significant operational and economic importance. Protective measures largely depend on paint systems which contain toxic compounds but the in-service life of such systems remains relatively short and unlikely to exceed two years [1,2]. Research therefore continues in an attempt to improve on the performance of the present anitfouling systems.

Experimental marine coatings undergo marine immersion trials to assess their efficiency. Such exposures require the type and abundance of fouling organisms to be reported, generally by personnel untrained in animal and plant identification. Identifications need to be accurate. However, in most instances, organisms need only be correctly assigned to general taxonomic groups and the overall abundance of the various groups reported. The identification of all organisms to species level would be a time-consuming and arduous task, and, although the results would be of considerable academic interest, the effort cannot be justified during routine exposure trials. However, the identification to species level of the most abundant and regularly occurring species can provide valuable information relevant to coating development.

A raft designed for testing marine coatings under static conditions was positioned at HMAS STIRLING in Cockburn Sound, Western Australia, in 1978. The raft was the first such facility on the west coast of Australia and complemented similar rafts on the eastern seaboard. Reports on fouling community composition and settlement characteristics at HMAS STIRLING have been published [3-5], but no readily-accessible publication has been available to facilitate the routine identification of species at this site. Earlier manuals of Australian fouling organisms [6-7], although drawn up from eastern

Australian fouling studies, serve as a useful guide to the principal groups of fouling organisms, particularly as most fouling groups and many fouling species are cosmopolitan in distribution. However, the differences between east and west, and taxonomic changes since publication of the earlier manuals warrant a new guide. The present report will enable the non-specialist to routinely identify the main fouling species and fouling types at HMAS STIRLING, and furthermore will act as a reference guide for the identification of fouling organisms in studies elsewhere in Australia.

The guide is divided into eight sections which each discuss a discrete taxonomic group of fouling organisms. In each section a general account of the features of the group is given, followed by descriptions of the main species collected at HMAS STIRLING. In all twenty-nine of the most abundant fouling organisms collected on panels attached to the HMAS STIRLING raft are described and illustrated. Illustrations are generally of the organisms as they occurred on short-term (approx. 1 month) panels rather than mature stages as the younger stages are more frequently met in routine panel trials. Described features apply equally to young and old individuals. Only macroscopic organisms have been included but a low-power magnifier (at least X10) may be required to observe identifying characteristics.

Further to the main species illustrated, less common species collected at the site are listed for each group. However, an exhaustive list of species reported from waters around HMAS STIRLING was considered beyond the scope of this guide and is not included. The majority of species in a fouling community occur only rarely and a community is generally structured around a few dominant species. For example, in a three-year study of fouling settlement at HMAS STIRLING 78 sessile species, excluding algae, were recorded [8]. Of these 48 (approx. 60%) were uncommon and only 10 (approx. 12%) were abundant community components. As mentioned previously the effort required to identify the usually large number of uncommon species cannot be justified in routine studies.

Finally a list of references is given for each group which indentifies where more detail on species or groups can be found, and to assist in further species identifications should these be required. Where known, both general and Australasian accounts of the fouling groups are referenced. Should an organism be encountered which cannot be readily assigned to one of the groups described herein, reference should be made to a more general text. Useful texts for this purpose include those by Gareth Jones and Eltringham [9], Gosner [10] and Barnes [11]. Additional detailed references to particular taxonomic groups are best sought in Sims [12].

2. ALGAE

2.1 *General*

Macroscopic fouling algae are usually members of one of three plant phyla: the Chlorophyta (green algae), the Phaeophyta (brown algae), or the Rhodophyta (red algae). A fourth group of fouling algae, the diatoms (Phylum Chrysophyta) are important primary colonisers of immersed substrata. Although some diatoms aggregate within branched gelatinous tubes, the majority cannot be observed with the naked eye and will therefore not be discussed further in this report. As the phylum names suggest, algal classification is partly based on the major pigments present in the plants' cells and, although differences also exist in the composition of cell walls and storage products, life histories, structure of reproductive bodies and ultrastructure, colour is a useful starting point in identification. Caution must be used however as some red algae can look brown, and some brown algae green. Microscopic examination of such plants may be necessary for correct identification.

Algae exhibit a wide range of growth forms from simple, unbranched chains of cells to complex thalli up to 8 m high differentiated into specialized structures for attachment, support, flotation and reproduction. Thalli can be single filaments, multiple filaments, finely-branched, coarsely-branched, beadlike, strap-like, thin sheets, thick sheets, inflated bladders, crusts, cushions, tufts or calcified. What is common to all is a requirement for light to permit photosynthesis and growth, and algae are therefore confined to the upper segment of the water column. Their actual vertical range varies and depends on local conditions of water clarity and the physiological requirements of individual species. In turbid harbour waters algae may only grow in the top metre or so whereas clear tropical waters can support algal growth at 50 or more metres.

2.2 *Common Species*

(i) *Enteromorpha compressa* (L.) Grev. (Chlorophyta, Ulvales, Ulvaceae)

(Bliding 1948:128-132, figs 5-10) Fig. 1a

E. compressa is a light to dark-green plant with a tubular thallus. The thallus walls are a single cell thick. The upper portion of the plant is often compressed and the lower portion narrows to a small attachment disk. Thalli are usually branched, which separates *E. compressa* from *E. intestinalis* (L.) Link. Thalli may arise singly or grow in clumps. Plants can grow to 40 cm tall.

(ii) *Ulva rigida* C. Ag. (Chlorophyta, Ulvales, Ulvaceae)

(Fletcher 1980:33, pl. 8, figs 3-6) Fig. 1b, c

U. rigida has a dark-green, flattened blade two cells thick. The blade is usually deeply-lobed and ruffled, thus the common description of *Ulva* spp. as 'sea-lettuce'. *U. rigida* differs to the commonly-reported *U. lactuca* L. in having cells 1.5-3 times longer than wide in section rather than subquadrate,and serrations along the lower margins of the blade. Plants can grow to 15 cm tall.

(iii) *Ectocarpus* spp. (Phaeophyta, Ectocarpales, Ectocarpaceae)

(Fletcher 1980:38, pl. 11) Fig. 1d,e

Ectocarpus spp. form light-brown tufts of monosiphonous (single-cell wide) filaments. Without the aid of a microscope the genus is difficult to separate from others in the family Ectocarpaceae. Generic charateristics are the ribbon-shaped chloroplasts (the photosynthetic pigment-containing bodies in the cells) and the form of the common fruiting bodies (plurilocular sporangia). Sporangia in *Ectocarpus* are usually borne on short stalks, are elongate and sometimes end in a colourless hair or occur within a filament.

Two species are recorded from southern Australia: *E. fasciculatus* Harv. and *E. siliculosus* (Dillw.) Lyngb. Generally *E. fasciculatus* is characterized by the upper filaments bearing closely-grouped, short side branches incurved toward the parent filament and sporangia in series. In *E. siliculosus* both side branches and sporangia are more widely spaced. However, many forms intermediate between the two species occur and their delimitation is unclear.

(iv) *Giffordia* spp. (Phaeophyta, Ectocarpales, Ectocarpaceae)

(Clayton 1974:164-190, figs 12-26) Fig. 1f

Plants form light-brown to greenish tufts as in *Ectocarpus*. *Giffordia* differs in having disc-shaped chloroplasts and plurilocular sporangia which are usually sessile (i.e. they have no stalk). Seven species of *Giffordia* have been recognised in southern Australia and these are separated on features of the branching pattern and sporangia shape. *G. irregularis* (Kuetz.) Joly, the species collected at the raft site, has irregular branching, and conical sporangia on one side of the filaments.

(v) *Polysiphonia* spp. (Rhodophyta, Ceramiales, Rhodomelaceae)

(Womersley 1979) Fig. 1g-m

Polysiphonia spp. are generally dark red to brownish-red in colour and grow as upright plants of multiply-branched filaments. Filaments are polysiphonous, ie. the primary row of cells cut off a number of cells which surround the primary filament (Fig. 1l-m). In some species the outer, or pericentral, cells cut off further small cells to form a layer, or cortex, which obscures the pericentral cells. Plants can arise from a single basal attachment point or from prostrate axes which run along the substrate surface. The number of pericentral cells can vary between species and, in Australian species, ranges from 4 to 12. Twenty-six *Polysiphonia* spp. are recorded from southern Australia.

Three species have been collected at the raft site: *P. subtilissima* Mont. and *P. infestans* Harv., both species with 4 pericentral cells but differing in size and growth form, and an unidentified species with 6 pericentral cells. *P. subtilissima* and *P. infestans* can both grow to 10 cm but are generally much smaller.

2.3 *Other Species*

(i) Chlorophyta

Bryopsis plumosa (Huds.) C. Ag. (Codiales, Bryopsidaceae)

(ii) Rhodophyta

Hypnea sp.	(Gigartinales, Hypneaceae)
Jania sp.	(Cryptonemiales, Corallinaceae)
Corallinaceae sp.	(Cryptonemiales, Corallinaceae)
Centroceras clavulatum (C. Ag.) Mont.	(Ceramiales, Ceramiaceae)
Ceramium sp.	(Ceramiales, Ceramiaceae)
Dasya sp.	(Ceramiales, Dasyaceae)

2.4 *References*

(i) General

Bliding, C. (1948). "Über *Enteromorpha intestinalis* und *compressa*." *Bot. Not.*, 1948, 123-136.

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(ii) Australasia

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Womersley, H.B.S. (1956). "A critical survey of the marine algae of southern Australia. 1. Chlorophyta." *Aust. J. mar. Freshwat. Res.*, 7, 344-383.

Womersley, H.B.S. (1979). "Southern Australian Species of *Polysiphonia* Greville (Rhodophyta)." *Aust. J. Bot*, 27, 459-528.

3. SPONGES (Phylum Porifera)

3.1 *General*

Sponges are the most primitive multicellular animals. In shape some are symmetrical but most are irregular and even within a species the shape can vary with different substratum types and degrees of water movement. Many sponges are brightly colour and can be green, yellow, orange, red or purple. Although some external morphological features such as colour, thickness and consistency are often uniform within a species, the taxonomy of the phylum largely depends on the composition and shape of the small, hard skeletal units, or spicules, which occur in almost all sponges.

The phylum is divided into three classes. The Calcarea (calcareous sponges) have calcareous spicules, are less than 10 cm in height, mostly drab in appearance and restricted to coastal waters. The Demospongiae can have siliceous spicules, spongin (a protein) fibres, a mixture of both, or no spicules at all. They are irregular in structure, show all types of growth and can occur in shallow or deep water. The third class, the Hexactinellidae (glass sponges), all have six-rayed siliceous spicules and are almost exclusively found in deep water. Generally sponges prefer clean water and relatively few of the 10,000 described species are found in the fouling communities of harbours and sheltered bays.

3.2 *Common Species*

(i) *Scypha ciliata* (Fabricius) (Calcarea, Heterocoelidae)

(Sarà 1974:18, figs 11-12, as *Sycon ciliatum*) Fig. 2a

Scypha ciliata has a tubular body constricted at each end, sometimes with a short stalk. A crown of needle-like spicules, which are pointed at each end and termed oxea, surrounds the opening, or oscule, at the upper end. The calcareous skeleton is constructed of oxea, triradiates (three-rayed spicules) and quadriradiates (four-rayed spicules). Individuals are generally 1-3 cm high and can be solitary or grouped in small clumps. The species has a cosmopolitan distribution.

3.3 *Other Species*

Several other species of calcareous sponge have been collected less commonly at HMAS STIRLING but these have not been identified.

3.4 *References*

(i) General

Sarà, M. (1974). *Catalogue of Main Marine Fouling Organisms, Volume 5, Marine Sponges,* Centre de Recherches et d'Études Oceanographiques, Boulogne, France. 42 pp.

Burton, M. (1963). *A Revision of the Classification of the Calcareous Sponges*, British Museum (National History), London, England. 693 pp.

4. HYDROIDS (Phylum Cnidaria, Class Hydrozoa)

4.1 *General*

Hydroids belong to the same phylum as large jelly-fish (Class Scyphozoa), and corals and sea-anemones (Class Anthozoa). Many have a two-stage life cycle with a sedentary polyp stage and a planktonic medusa stage. An individual hydroid polyp (hydranth) is like a minute sea-anemone being essentially cylindrical in body shape, basally attached, with a central mouth on the upper end surrounded by a ring of tentacles. A hydroid medusa resembles a small jellyfish. Although some hydroids exist as solitary polyps in the sedentary polypoid stage, the majority have colonial polyps with each polyp interconnected by a network of fine tubes. Such hydroids often occur in fouling communities.

Colonies have a wide variety of growth forms. Generally the colony is attached to the substratum by a procumbent root-like structure (the hydrorhiza). In some species polyps arise directly from the hydrorhiza but more often they grow on erect branched or unbranched stems (hydrocauli) which grow up from the hydrorhiza. The living tissue in a colony is wholly or partially surrounded by a chitinous envelope (the perisarc) which is either confined to the hydrorhiza and stems (Order Athecata) or continues to form a protective cup (hydrotheca) around the hydranth (Order Thecata). Cups vary from open-ended, bell-shaped structures to vase-like structures with hinged flaps which can close over the retracted hydranth.

4.2 *Common Species*

(i) *Tubularia ralphi* Bale (Athecata, Tubulariidae)

(Watson 1980:60-61, figs 25-37) Fig. 2b-c

T. ralphi stems grow in dense tufts from an intertwined mat of hydrorhiza. The straw-coloured stems are usually unbranched with groups of 3-8 annulations at intervals along their length. Each stem has a terminal hydranth. Hydranths have two whorls of unbranched tentacles and are often orange-red with white tentacles. However, colour is variable. Reproductive bodies (gonophores) are borne on modified hydranths (blastostyles) which arise above the lower whorl of tentacles. Colonies can grow to 12 cm high with individual stems of up to 0.5 mm diameter.

(ii) *Obelia* sp. (Thecata, Campanulariidae)

(Cornelius 1975) Fig. 2d,e

Erect stems of *Obelia* spp. grow up from creeping hydrorhiza. The stems often grow sympodially, i.e. each new hydranth buds from the stem a little below the terminal hydranth, overtakes it and becomes the new terminus. Upright growth therefore assumes a zig-zag form. The hydranths are protected by bell-shaped hydrothecae which are terminal on short stalks (pedicels). Hydrothecal margins can be smooth or toothed. The reproductive zooids are encased in urn-shaped structures (gonothecae) and produce free medusae.

The STIRLING specimens are small, the tallest only 6 mm high. Hydrothecae are smooth-rimmed, clearly wider than long, and borne on short pedicels which commonly have two but may have up to seven annular rings. There are usually three annular rings on the main stem above the junctions of the pedicels. In the absence of gonotheca the species has not been identified but it is readily separable from *O. australis* von Lendenfield (= *O. dichotoma* (Linnaeus)) and *O. geniculata* Linnaeus, both species with smooth hydrothecal margins commonly reported from southern Australian waters, by the shape of the hydrothecae and the absence of a thickened 'knee' on the main stem at the base of the pedicels.

4.3 *Other Species*

Hydractiniid sp.	(Athecata, Hydractiniidae)
Campanularia johnstoni Alder	(Thecata, Campanulariidae)
Obelia bidentata Clark	(Thecata, Campanulariidae)

4.4 *References*

(i) General

Millard, N.A.H. (1975). "Monograph of the Hydroida of southern Africa." *Ann. S. Afr. Mus.*, 68, 1-513.

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Watson, J.E. (1980). "The identity of two tubularian hydroids from Australia with a description and observation on the reproduction of *Ralpharia magnifica* gen. et sp. nov. " *Mem. natn. Mus. Vict.*, 41, 53-63.

5. TUBEWORMS (Phylum Annelida, Class Polychaeta)

5.1 *General*

Marine polychaete worms, commonly known as bristle worms, have either a free-swimming (errant) or a sedentary life-style. Some sedentary polychaetes burrow into soft substrates whilst others build tubes of calcium carbonate or sand and mud particles bound with mucilage. The tube-building polychaetes, particularly those with calcareous tubes (the families Serpulidae and Spirorbidae), are common fouling organisms.

The body of a polychaete worm is segmented with paired bundles of bristles (setae) on each segment. In serpulids each bundle has a bunch of long, needle-like, capillary setae and a row of hooked setae (uncini) used to grip the inside of the tube. The anterior part of the body, the thorax, is wrapped in a cloak-like thoracic membrane and crowned with long, feathery tentacles (branchial filaments) which are used to draw food and oxygen from the water. The end of one filament is often expanded to form an operculum which is used to plug the opening of the tube when the worm retracts inside.

Some species can be recognised from features of the tube but more often the worm must be extracted from the tube and examined for certain identification. Features of the operculum and setae are commonly used in species diagnoses.

5.2 *Common Species*

(i) *Serpula vermicularis* Linnaeus (Sabellida, Serpulidae)

(Nelson-Smith 1967:24, figs 5-7) Fig. 2f-g

S. vermicularis has a funnel-shaped operculum, the distal surface of which is slightly concave and bears 15-80 radial grooves that divide the rim into numerous teeth. The white or pinkish tube usually has one or more longitudinal ridges and is subcircular in cross section. Tubes can be up to 70 mm long and 4 mm in diameter.

Serpula spp. can be superficially similar to *Hydroides* spp. but the latter differs in having a secondary crown of spines surmounting the opercular funnel.

(ii) *Filograna implexa* Berkeley (Sabellida, Serpulidae)

(Nelson-Smith 1967:48-49, figs 42-44) Fig. 2h-i

F. implexa has fine white cylindrical tubes with occasional growth rings. The worms are gregarious and tubes often twist about each other to former irregular rope-like colonies. In some forms there is no operculum whilst in others a small operculum is borne on a stalk which closely resembles the other branchial filaments. Tubes can reach 50 mm long and 0.5 mm diameter. *Filograna* can reproduce asexually with new individuals budded off parent worms and this capability contributes to colony expansion.

Filograna implexa has, in the past, been commonly reported as *Salmacina dysteri*. However these two names have been shown to refer to the same species and the name *S. dysteri* is now considered synonymous with *F. implexa*.

(iii) Spirorbid spp. (Sabellida, Spirorbidae)

(Knight-Jones *et al.* 1974) Fig. 2j-k

Spirorbid tubes are closely pressed to the substratum and coiled in a regular spiral. They are generally less than 5 mm. across the outer wall. The operculum has a calcareous cap and in some species is expanded to form a brood chamber for the incubation of embryos.

Until recently the family was considered to contain only one genus, *Spirorbis*, but this is now spilt into a number of genera on features of the tube, setae and mode of embryo incubation. The small size of spirorbid individuals makes indentification difficult but two species have been identified from HMAS STIRLING, *Janua pagenstecheri* (Quatrefages) and *Pileolaria militaris* Claparède. The genus *Janua* can be easily recognised by the dextral (mouth faces anticlockwise) coiling of the tube. In all other genera coiling is sinistral (mouth faces clockwise). *Pileolaria* differs to other sinistrally-coiled genera in setal characteristics and use of an opercular brood chamber.

5.3 *Other Species*

Polydora spp.	(Spionida, Spionidae)
Hydroides elegans (Haswell)	(Sabellida, Serpulidae)
H. brachycantha Rioja	(Sabellida, Serpulidae)
Galeolaria hystrix (Mörch)	(Sabellida, Serpulidae)
Pomatoceros taeniatus (Lamarck)	(Sabellida, Serpulidae)

5.4 *References*

(i) General

Nelson-Smith, A. (1967). *Catalogue of Main Marine Fouling Organisms, Volume 3, Serpulids,* O.E.C.D. Publications, Paris, France. 79 pp.

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6. MOLLUSCS (Phylum Mollusca)

6.1 *General*

Molluscs typically secrete a protective shell of calcium carbonate. Shells assume a wide range of forms and may be whorled, tubular, cup-shaped, simple plates or, in some species, be absent altogether. Only three of the molluscan classes are likely to be found in fouling communities: the Polyplacophora (chitons), Gastropoda (snails and slugs) and Bivalvia. The shells of chitons comprise eight shield-like plates, gastropods a single whorled or cup-shaped structure and bivalves two symmetrical or near-symmetrical compressed valves. Chitons and gastropods are generally mobile and are found searching for food on and between attached fouling species. One exception is the vermatid gastropods whose coiled, tubular shells resemble those of serpulid polychaetes and are similarly cemented to the substratum. The soft animal parts retain molluscan features however and, although a calcareous operculum may be present, vermatids lack the branchial crown of feeding tentacles seen in serpulids.

Bivalves are the most significant of the fouling molluscs. The animal is laterally compressed and the two more or less symmetrical halves of the shell are hinged dorsally. Many bivalves burrow in soft substrata and some, for example scallops, can swim, but the important fouling species are permanently or semi-permanently attached to the substratum. Attachment is either by cementing one valve of the shell to the substratum or by secreting specialised horny threads (byssal threads) through a gap between the valves or through a hole in the lower valve.

6.2 *Common Species*

(i) *Mytilus edulis* Linnaeus (Pteroconchida, Mytilidae)

(Macpherson & Gabriel 1962:293, fig. 335, as *M. planulatus*)

Fig. 3a-c.

The wedge-shaped shells of *Mytilus edulis*, the common mussel of southern Australian harbours and sheltered bays, are purplish-black externally and bluish-white internally. Newly settled individuals are brown. The two valves are symmetrical and bear concentric growth lines. The hinge and umbo (the swollen portion of shell above the hinge) are terminal and a small number of teeth occur on the internal margins just anterior to the umbo. Shells are attached by a bundle of byssal threads which passes between the valves on the antero-dorsal margin. Shells can grow to 10 cm and generally grow in dense aggregations just below the water surface. In Australia this species was known as *M. planulatus* (Lamarck) but is now considered a subspecies of the cosmopolitan *M. edulis*.

(ii) *Anomia trigonopsis* Hutton (Pteroconchida, Anomiidae)

(Macpherson & Gabriel 1962:311, fig. 352, as *Monia ione*)

Fig. 3d-f

Commonly known as "jingle shells", *Anomia trigonopsis* shells are yellowish-golden, thin and brittle. The upper valve is convex and is irregularly, radially ridged. The lower valve is often flat but conforms to the shape of the substratum. The outline of the shell is often subcircular but again this can be greatly influenced by the surroundings. Shells are attached by a byssus which protrudes through a conspicuous hole in the lower valve. Juvenile shells are almost transparent with the animal body readily visible through the upper valve. Adults grow to about 6 cm diam.

(iii) *Ostrea* spp. (Pteroconchida, Ostreidae)

(Thomson 1954:140-141, 143-149, pls 1-4). Fig. 3g-i

Oysters of the family Ostreidae have a thick calcareous shell with the lower valve partially or entirely cemented to the substratum. The shells of the genus *Ostrea* differ to those of *Crassostrea* in having a shallow rather than deeply cup-shaped lower valve, no recess in the lower valve under the hinge and the muscle scar positioned almost centrally rather than displaced toward the lip. The third Australian ostreid genus, *Pycnodonte*, differs to the forementioned genera in having the muscle scar elevated on a shelf-like projection. All three genera differ in anatomical features and, as the shell form can be quite variable, soft parts are often required for certain identification.

Two *Ostrea* species are known from from HMAS STIRLING: *O. folium* Linnaeus and *O. angasi* Sowerby. *O. folium* shells are generally bronze-red externally, opalescent white internally and the shell lips are often strongly crenulated, whilst in *O. angasi* the shells are greyish-white externally, chalky-white with a brown border internally, and the shells lips are, at most, wavy. The two species also differ anatomically. *O. folium* is more common than *O. angasi*.

6.3 *Other Species*

Hiatella australis (Lamarck) (Heterodontida, Hiatellidae)

6.4 *References*

(i) Australasia

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7. CRUSTACEANS (Phylum Arthropoda, Class Crustacea)

7.1 *General*

The crustaceans are a diverse assemblage of mostly aquatic organisms which include crabs, prawns, lobsters and sand fleas. They differ from other classes of arthropods, such as, insects by having two pairs of antennae together with jaws (mandibles). The majority of crustacean species are free-living and are therefore unimportant as structural components of fouling communities. There are however some exceptions, the most notable being the barnacles.

Superficially the adult barnacle bears little resemblance to its free-living relatives as the body is enclosed within a calcareous shell cemented to the substratum. In the balanomorph or acorn barnacles, the common fouling barnacles of inshore waters, the shell consists of fixed wall plates shaped like a truncated cone. The opening at the upper end is covered by two pairs of opercular plates which are retracted when the animal feeds. The soft body parts are also modified for a sedentary existence with, for example, swimming legs modified as feeding arms (cirri) which filter food particles from the water.

The second group of crustaceans which can be important foulers are the tube-dwelling amphipods. These will be discussed further below.

7.2 *Common Species*

(i) *Balanus trigonus* Darwin (Thoracica, Balanidae)

(Lewis 1981:11, fig. 5d, pl. 4c-d). Fig. 3j-k

The shell of *Balanus trigonus* is pinkish and, as with other species of the genus *Balanus*, consists of six wall plates. The wall plates of this species have raised longitudinal ribs and a single row of internal tubes. One pair of opercular plates (the scutae) are dissected by longitudinal furrows and transverse growth ridges to form rows of pits on the outer surface. The barnacle shell sits on a subcircular calcareous base.

(ii) *Balanus variegatus* Darwin (Thoracica, Balanidae)

(Lewis 1981:10, figs 5c, 6a, pl. 4 a-b). Fig. 3l-m

B. variegatus shell plates are smooth, cream-coloured and cross-hatched by longitudinal and transverse purple bands. The opercular plates may bear transverse growth ridges but do not have longitudinal furrows. As in *B. trigonus* the six wall plates have a single row of internal tubes and the shell sits on a calcareous base. When growing in dense colonies the shell often assumes a tubular shape.

(iii) Gammarid spp. (Amphipoda, Suborder Gammaridea)

(Barnard, 1969) Fig. 3n

Amphipods occur in almost all marine habitats, both benthic and planktonic, at all depths, and on all substrata. Adults are generally between 2 and 40 mm long and the body is compressed from side to side. The tube-dwelling amphipods either construct tubes by cementing together sand, mud, shell or other debris or live in tubes built by other organisms. Those collected at HMAS STIRLING built tubes from fine sediment particles and numerous tubes were generally clumped together.

7.3 *Other species*

Balanus amphitrite amphitrite Darwin (Thoracica, Balanidae)

7.4 *References*

(i) General

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8. BRYOZOANS (Phylum Bryozoa)

8.1 *General*

Bryozoans grow as sedentary colonies in which a large number of individuals (zooids) are joined in various ways. They show a variety of habits which include tufted, encrusting and stolonate forms. Each zooid consists of a living animal (polypide) encased in a chitinous shell which may or may not have an additional calcareous exoskeleton (zooecium). Each zooecium is generally less than 0.5 mm long and is box-like with an opening (orifice) through which the tentacles are extended for feeding. The orifice can usually be closed with a pleated membrane or horny operculum. Marine bryozoa are divided among three orders: the calcified Cyclostomata and Cheilostomata, and the uncalcified Ctenostomata. The Cyclostomes differ to the Chielostomes in the terminal rather than frontal or subterminal position of the orifice and the mode of eversion of the tentacles. Cheilostomes are further divided into Anascans, which have a large uncalcified area on the frontal wall, and Ascophorons in which the frontal wall is almost completely calcified. In many Cheilostomes, embryos develop in special chambers called ovicells which overhang the orifice and modified zooids called avicularia and vibraculae are often present.

8.2 *Common Species*

(i) *Watersipora* spp. (Cheilostomata, Watersiporidae)

(Ryland 1974:345-346, fig. 3). Fig. 4a-c

Watersipora colonies are dark-reddish brown to black, encrusting, with zooecia about 1 mm long and 0.25 - 0.5 m wide. The frontal wall of the individual zooecia is perforated by numerous large pores. Spines, avicularia and ovicells are absent. The orifice is rounded with a darkly pigmented operculum and a pair of protuberances (condyles) on its proximal margin. Two species have been collected at HMAS STIRLING: *W. arcuata* Banta and *W. subovoidea* (d'Orbigny). *W. arcuata* differs to *W. subovoidea* in having a concave rather than convex proximal margin to the orifice.

(ii) *Schizoporella errata* (Waters) (Cheilostomata, Schizoporellidae)

(Hayward & Ryland 1979:170, Fig. 68) Fig. 4d-e

S. errata colonies are encrusting and whitish-pink in colour. Zooids are rectangular or lozenge-shaped and the frontal walls are perforated by pores sunk in pits. The orifice is as wide as long and has a semi-circular distal margin. More than half the width of the proximal margin is excavated to form a convex sinus. A single avicularium is often present beside the orifice. Ovicells, when present, are prominent, globular in shape and perforated by small pores.

(iii) *Bugula* spp. (Cheilostomata, Bugulidae)

(Ryland & Hayward 1977:167, fig. 78, *B. neritina;* 170, fig. 82, *B. stolonifera)* Fig. 4f-h

Bugula spp. have branching erect colonies. Boat-shaped zooids grow in two or more series and alternate across the width of the branch. Two species are common at HMAS STIRLING: *B. neritina* Linnaeus and *B. stolonifera* Ryland. *B. neritina* is purplish brown when living, translucent brown when dead and has two series of zooids across branches. There are no spines on the distal margins and no avicularia. Ovicells are attached to the inner distal angles of the zooids. The buff-coloured colonies of *B. sto o ifera* also have two series of zooids across the branches. However the zooids have one spine on the inner distal angle of the zooecium and two, or rarely three, on the outer angle. Avicularia, shaped like birds' heads, are also frequently present on the lateral margins. *B. neritina* tufts reach a height of 8 cm whilst those of *B. stolonifera* are generally less than 4 cm.

8.3 *Other Species*

Bugula flabellata (Thompson)	(Cheilostomata, Bugulidae)
Tricellaria sp.	(Cheilostomata, Scrupocellariidae)
Microporella sp.	(Cheilostomata, Microporellidae)
? Umbonulid sp.	(Cheilostomata, Umbonulidae)

8.4 *References*

(i) General

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9. ASCIDIANS (Phylum Chordata, Class Ascidiacea)

9.1 General

There are two principal types of ascidian: solitary and colonial. Solitary, or simple, ascidians are those with separate relatively large individuals and are often called 'sea-squirts'. One end of the animal is attached to the substratum whilst the other has two openings that may be extended as two separate siphons. Water is drawn into the branchial sac through one opening, (the oral or buccal opening) and expelled through the other (the atrial or cloacal opening). The body is covered by an outer layer, the test or tunic, which may be soft and semi-transparent or thick and leathery.

Colonial, or compound ascidians divide by budding to create many small individuals (zooids) within a common matrix. This matrix is the equivalent of the test in solitary forms. Zooids are usually less than 5 mm long and may be arranged in definite groups (systems) or be without apparent order. The tests of some species contain small calcareous bodies called spicules.

9.2 *Common Species*

(i) *Trididemnum* sp. (Enterogona, Didemnidae)

(Kott 1962:274-283, figs 5-13) Fig. 5a-b

The zooids of *Trididemnum* are embedded in a thin encrusting sheet which may or may not have calcareous spicules. The zooid body is divided into a thorax and abdomen and the walls of the branchial sac are perforated by three transverse rows of slits (stigmata). The abundant spicules in the species collected at HMAS STIRLING almost obscure the light brown zoids and colour the colony white.

(ii) Unidentified colonial spp. Fig. 5c-h

Three other colonial species occurred commonly on panels from the raft but these have not been identified. All form thin crusts. Species 1 (Fig. 5c-d) has dark red zooids loosely arranged in linear systems. A dense ring of pigment encircles the oral opening and there are no spicules in the translucent test. Species 2 (Fig. 5e,f) has whitish zooids with some brown markings. Small clusters of spicules are spread through the almost transparent tests. In Species 3 (Fig. 5g,h) the zooids have a brown thorax and creamy white abdomen. Again the test is almost transparent but there are no spicules.

9.3 *Other Species*

(i) Solitary

Ascidia aspersa (Muller)	(Enterogona, Ascidiidae)
Corellid sp.	(Enterogona, Corellidae)
Microcosmus claudicans Savigny	(Pleurogona, Pyuridae)
Molgula batemani Kott	(Pleurogona, Molgulidae)
Styela irma (Hartmeyer)	(Pleurogona, Styelidae)

(ii) Colonial

Botrylloides leachii (Savigny)	(Pleurogona, Styelidae)
Symplegma viride Herdman	(Pleurogona, Styelidae)

9.4 *References*

(i) General

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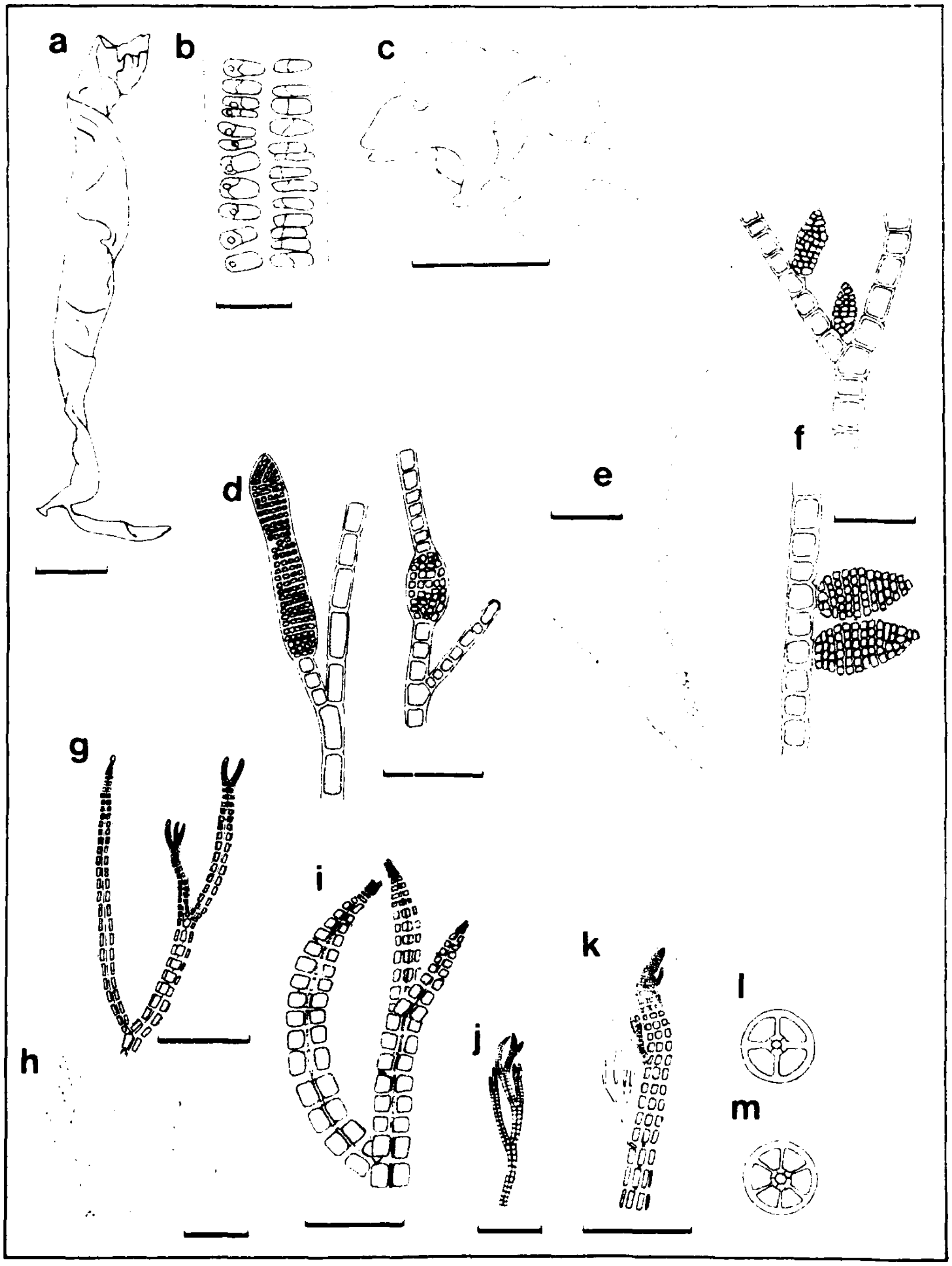

FIG. 1. ALGAE a. *Enteromorpha compressa* (young plant); b,c. *Ulva rigida* (b, cross-section; c, young plant); d,e. *Ectocarpus fasciculatus* (d, plurilocular sporangia; e, branching pattern); f. *Giffordia irregularis* (plurilocular sporangia); g,h. *Polysiphonia subtilissima* (g, branch apices; h, young plant); i,j,l. *P. infestans* (i, branch apex; j, young plant; l, diagramatic transverse section); k, m. *Polysiphonia*. sp. (k, branch apex, m, diag. trans. section). Scale bars: a,c = 5 mm; h,j = 1 mm; b,d,f = 50 um; e,g,k,i - 250 um.

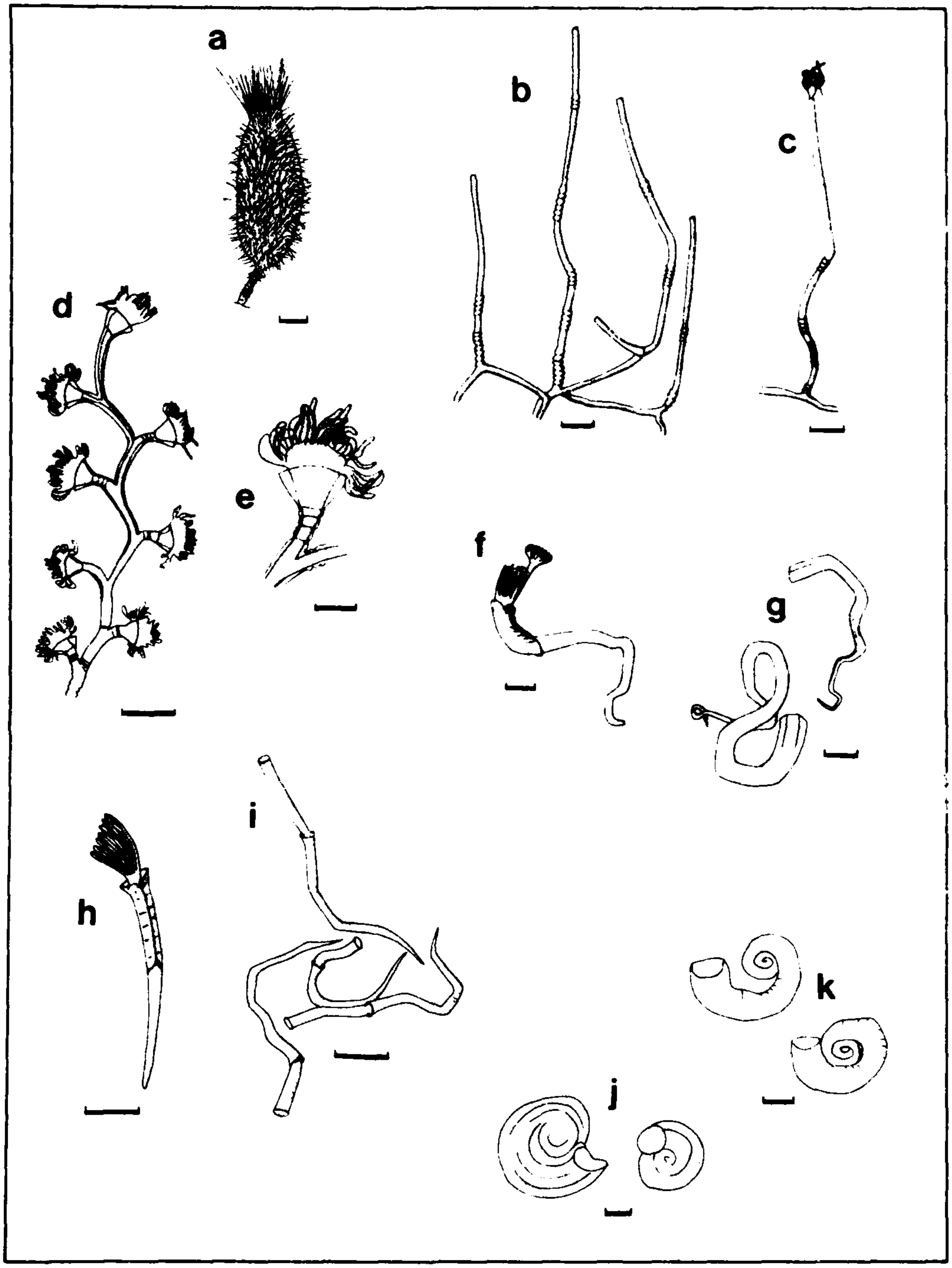

FIG. 2. SPONGES a. *Scypha ciliata* (whole animal)
HYDROIDS b,c. *Tubularia ralphi* (b, hydrocauli, c. hydrocaulus with hydranth); d,e *Obelia* sp. (d. hydrocaulus; e. single hydranth);
TUBEWORMS f,g. *Serpula vermicularis* (f, wrom; g, tubes); h,i *Filograna implexa* (h, worm; i, tubes); j. *Janua pagenstecher.* (tubes); k. *Pileolaria militaris* (tubes)
Scale bars: a-d, j-k = 1 mm; e = 250 um f-i = 2 mm.

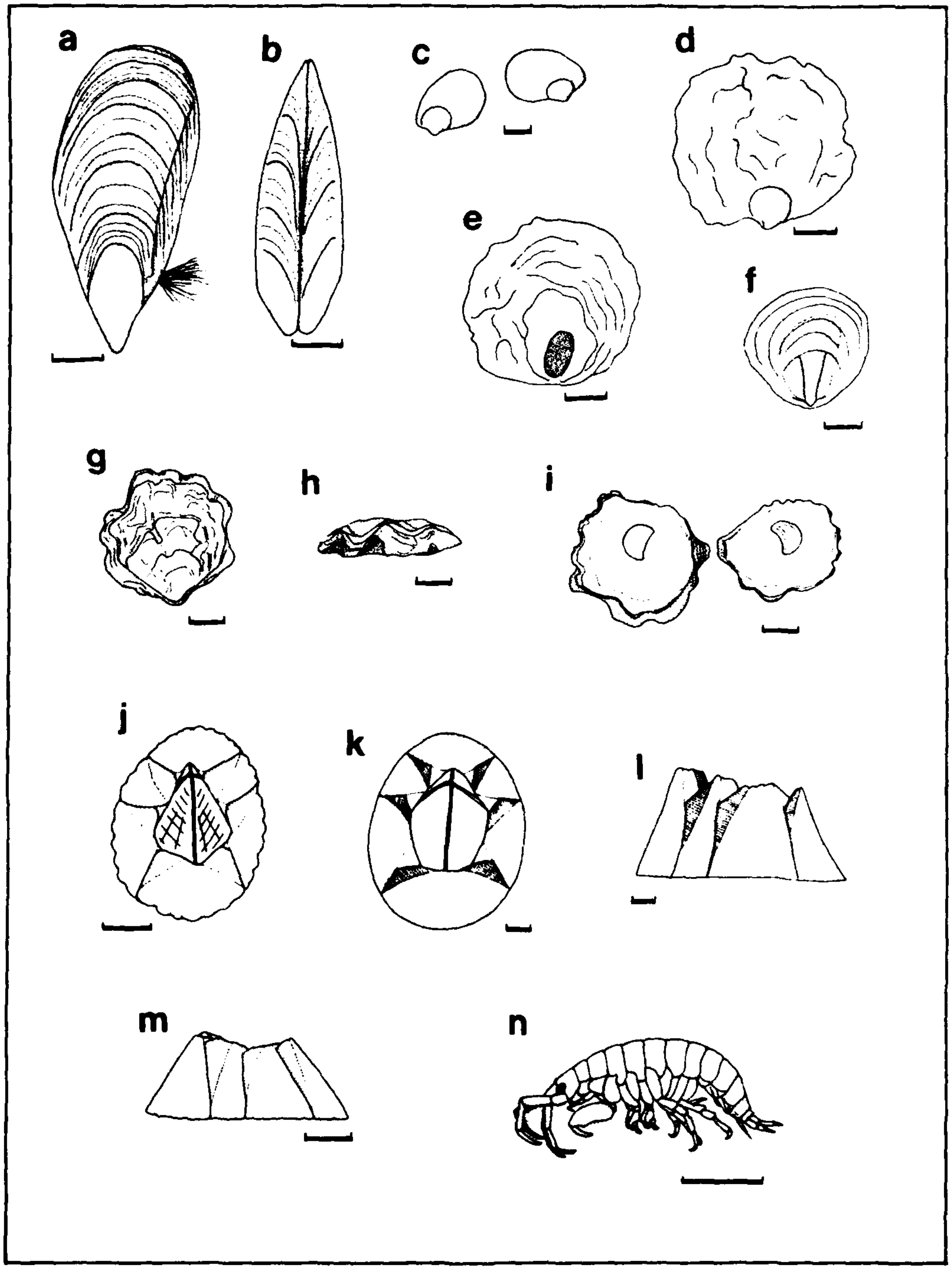

FIG. 3. MOLLUSCS a-c *Mytilus edulis* (a,b,adult; c. juveniles); d-f *Anomia trigonopsis* (d, upper valve; e, lower valve; f, juveniles); g-i *Ostrea* sp. (g, upper view; h, lateral view; i, interior).
CRUSTACEA j,k *Balanus trigonus* (j, surface view; k, lateral view); l,m *Balanus variegatus* (l, surface view, m, lateral view); n Gammarid sp. (whole animal)
Scale bars: a-b, d-e, g-i = 1cm; c,f,j-n = 2 mm.

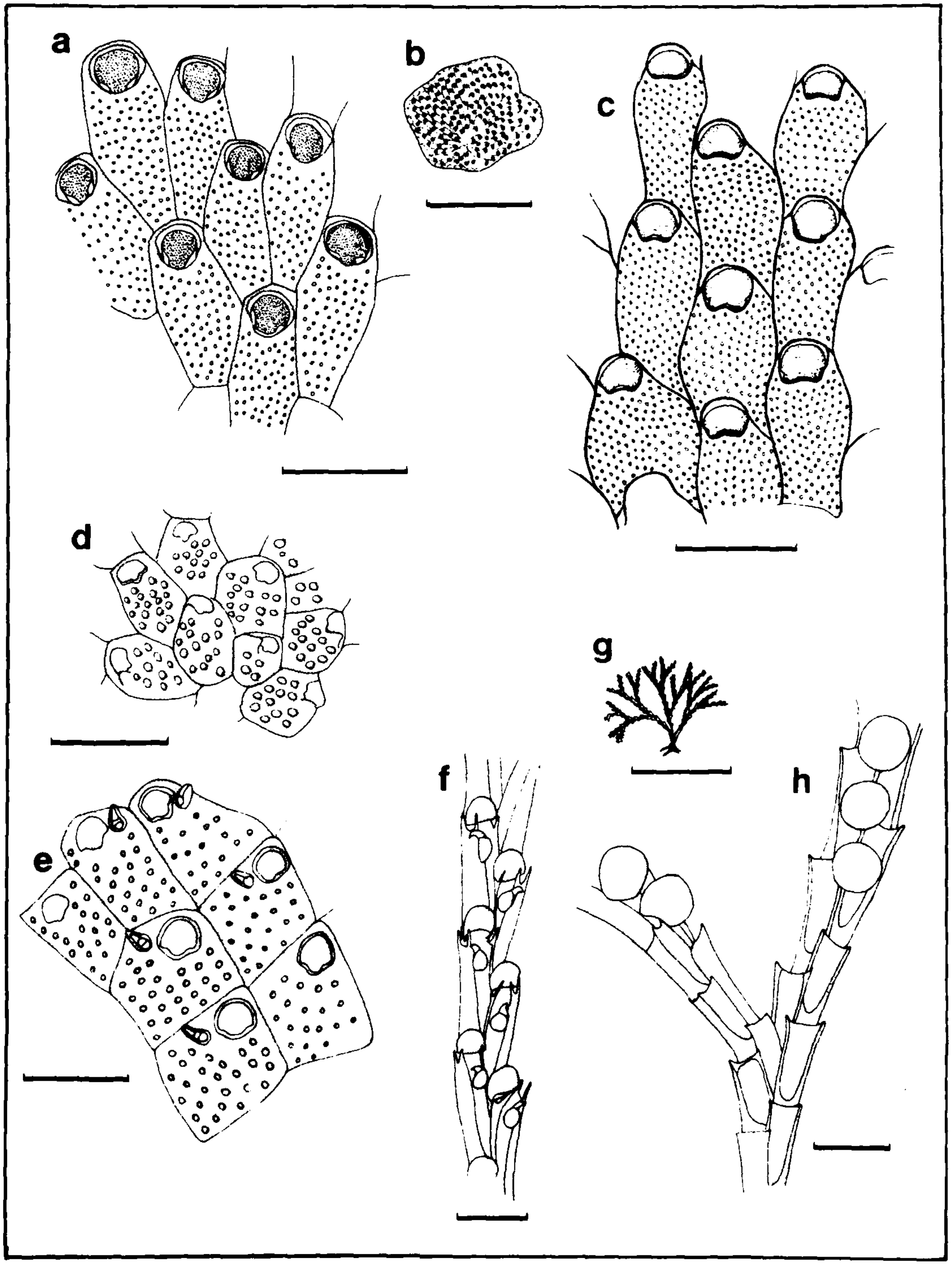

FIG. 4. BRYOZOA a-b *Watersipora subovoidea* (a, zooecia; b, colony); c *W. arcuata* (zooecia); d,e *Schizoporella errata* (d, young zooecia; e, mature zooecia); f *Bugula stolonifera* (zooecia); g-h *B. neritina* (g, young colony; h, zooecia).
Scale bars: a,c-f,h = 500 um, b = 5 mm, g = 1 cm

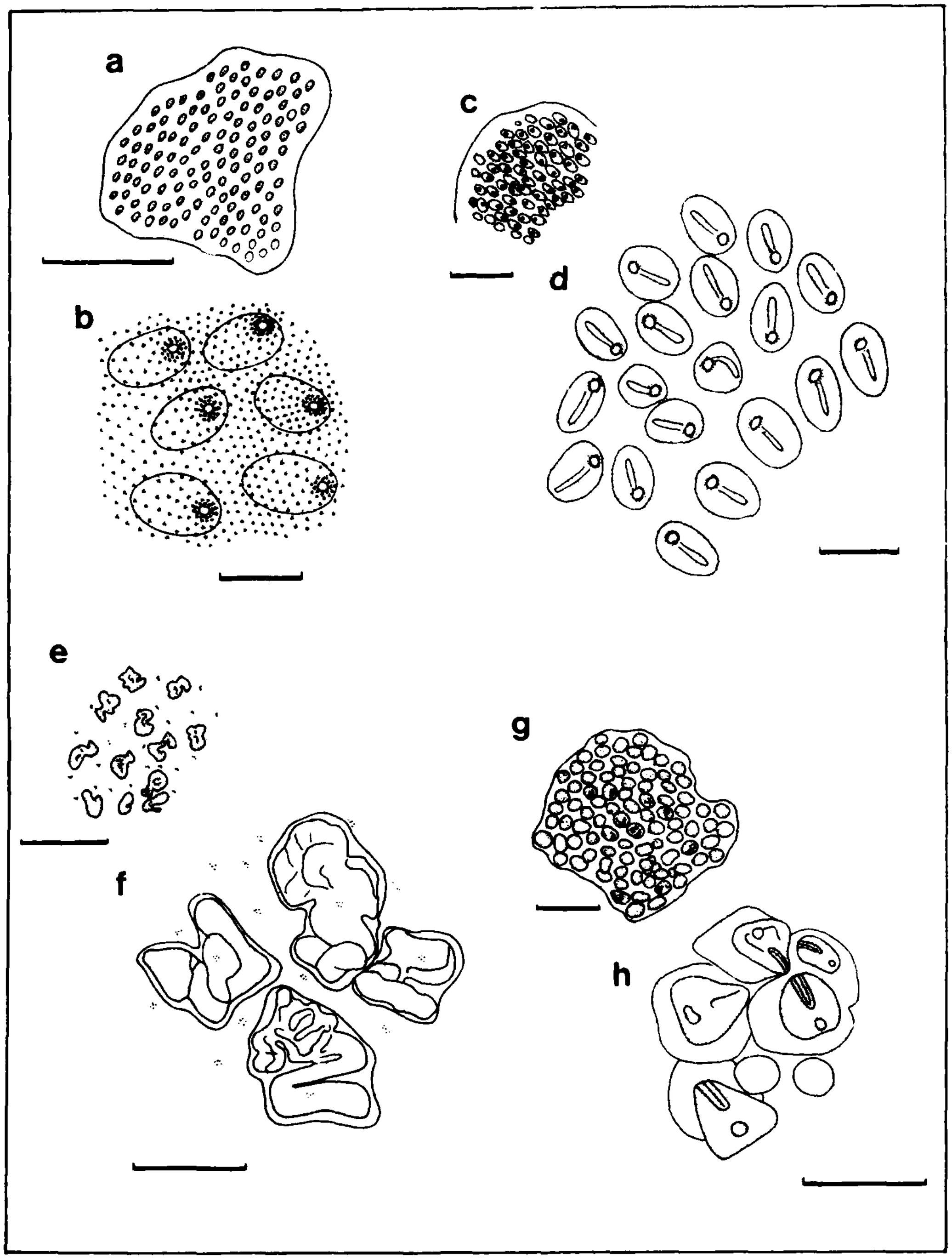

FIG. 5. ASCIDIANS a-b *Trididemnum* sp. (a, colony; b, zooids); c-d Unidentified colonial sp. 1 (c, colony; d, zooids); e-f, Unid. colonial sp. 2 (e, colony; f, zooids); g,h, Unid. colonial sp. 3 (g, colony; h, zooids).
Scale bars: a = 5 mm; b,f,h = 5 u; c,e = 2 mm; d = 1 mm.

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